Province of
British Columbia

Ministry of
Environment

Fisheries
Branch

FEASIBILITY STUDY

OF ESTABLISHING FISH FEED MANUFACTURING FACILITIES

IN BRITISH COLUMBIA

April 1985

DON FERENCE
& ASSOCIATES LTD.
Management Consultants

B.C. MINISTRY OF ENVIRONMENT

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FOREWORD

The Ministry of Environment is committed to the commercial fisheries and mariculture policies approved by Cabinet in March, 1980, which create an improved climate for investment in aquaculture and ensure that the best use is made of the marine environment.

This information report supports these policies by providing the prospective investor with an initial feasibility study. The report discusses the existing and potential market for fish feeds, the primary resource inputs, the major cost factors and a financial evaluation. The potential investor, after reading this report is in a better position to decide whether or not to pursue an interest in feed manufacture and thereby move to the next step of evaluating his particular business situation. The silage section is of particular use to fish farmers and fish processing plants.

Considerable economic benefit may be derived from aquaculture for both private enterprise and the total economy of British Columbia. Rational decisions by informed decision-makers will assure the maximum attainment of this benefit, including the best use of marine resources. This report should be viewed as one step in the decision process.

James E. Fralick
Head
Finfish Policy and Resource Development Unit

DON FERENCE
& ASSOCIATES LTD.

ACKNOWLEDGEMENTS

This study was funded by a grant from the Marine Resources Section of the B.C. Ministry of Environment. The role of the Marine Resources Section is to facilitate the development of the mariculture industry in British Columbia.

The consultants acknowledge with gratitude the assistance and co-operation received from the numerous government and private organizations and individuals during the preparation of this report.

The responsibility for the report, as written, and all conclusions reached herein, are the consultants alone, and the report does not necessarily reflect the opinion of those who assisted during the course of the investigation or the provincial government which funded the study.

EXECUTIVE SUMMARY

SCOPE OF STUDY

The major purpose of the study is to assess the need for and viability of establishing additional fish feed manufacturing facilities in B.C. to supply the local fish farming industry. In addition, the study assessed the feasibility of using fish silage as an alternative to conventional fish feeds.

METHOD OF STUDY

In order to undertake the study, we contacted representatives of fish farms, government fish hatcheries, and fish feed mills to determine the size of the market of fish feed in western Canada and the U.S. Pacific Northwest. To determine the likely operating and capital costs to establish a fish feed mill, we contacted representatives of feed mills and equipment suppliers. We also contacted representatives of fish silage plants and equipment suppliers in Norway to assess the likely capital and operating costs of a fish silage system.

CONCLUSIONS

A summary of our major conclusions regarding the viability of establishing additional fish feed manufacturing facilities in B.C. is provided below:

1. The total market for fish feed in B.C. in 1984 is estimated to be about 1,410 tonnes.

   Of this total, dry fish feed accounted for 695 tonnes while the balance consisted of moist feed and semi-moist feed.

2. B.C. feed mills supplied approximately 410 tonnes of dry feed pellets or 29% of the total B.C. fish feed market in 1984.

   The remainder of the fish feed consumed in B.C. was imported from the U.S. and consisted primarily of moist and semi-moist fish feed.

3. There currently exists excess dry fish feed production capacity in B.C.

   The major fish feed producer in B.C. has recently purchased additional equipment to increase total production capacity to about 10,000 tonnes per year.

4. The market for fish feed in B.C. is likely to increase considerably within the next five years.

   The major growth is likely to result from an expansion of the commercial salmon farming sector which consumed primarily dry fish feed. While it is difficult to predict the likely rate of growth, some of the industry representatives contacted have indicated that the projected increase in salmon production could increase total feed consumption to as much as 10,000 tonnes by 1990. As a result, the production capacity of the existing fish feed producers in B.C. could possibly be reached within the next five years.

5. The breakeven sales volume of a dry pelleted fish feed mill in B.C. is estimated to be approximately 4,590 tonnes. As a result, the fish feed market in B.C. will have to expand considerably before it would be viable to construct an independent fish feed mill in B.C.

6. There exists potential to reduce current feed costs through the use of fish silage as a substitute for fish meal in the manufacture of fish feed.

   The fish silage could either be produced on-farm or in a large scale plant and then mixed with binder meal at the fish farm. The production of silage based feeds is heavily dependent upon close proximity to an adequate supply of fish waste. In addition, due to the lack of conclusive information regarding the feed conversion rate of fish silage, it is difficult to accurately assess the viability of silage based feeds.

RECOMMENDATIONS

Based upon our study findings, our recommendations are as follows:

1. Additional dry fish feed manufacturing facilities should not be established in B.C. until the market demand is sufficient to achieve the breakeven volume of a fish feed mill.

2. Research should be undertaken as soon as possible to determine the feed conversion rate and suitability of using fish silage as an alternative for fish meal in commercial fish farm diets.

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Appendix 1 Raw Material Costs of Dry Salmon Fish Feed
Appendix 2 Cost of Binder Meal for Silage Based Feed

1. SCOPE OF THE STUDY

This study was commissioned by the Marine Resources Section of the B.C. Ministry of Environment. One of the major objectives of the study is to assess the need for and viability of establishing additional feed manufacturing facilities in B.C. to supply the local fish farming industry. The second objective of the study is to assess the feasibility of utilizing fish silage as an alternative to conventional fish feeds.

In order to undertake the study, we first conducted an extensive literature review to obtain the available statistics and published information on the production and consumption of fish feed in Canada, the United States and Europe. A detailed list of the publications and studies that we reviewed is provided in the bibliography at the end of the report.

In order to determine the size of the local market for fish feed, we conducted interviews with the major salmon and trout producers in B.C. and Washington. We also contacted representatives of federal, provincial and state governments in B.C., Alberta and Washington to determine the current and projected demand for fish feed by government sponsored hatchery programs. A list of the individuals contacted is provided below:

- Mr. Doug Harpham
  Sea Spring Salmon Farm Ltd.
  Chemainus, B.C.

- Mr. Brad Hope
  Tidal Rush Marine Farms Ltd.
  Saltery Bay, B.C.

- Mr. Ben Lehman
  Sun Valley Trout Farms Ltd.
  Mission, B.C.

- Mr. Tom May
  Cockburn Bay Sea Farm
  Garden Bay, B.C.

- Mr. Edward P. Brauer
  Manager, Research and Development
  Domsea Foods Inc.
  Bremerton, Washington

- Mr. Ed Britton
  Assessment Biologist
  Fisheries and Oceans Canada
  Vancouver, B.C.

- Mr. Hugh Sparrow
  Head, Fish Culture
  Fish & Wildlife Branch
  B.C. Ministry of Environment
  Vancouver, B.C.

- Mr. Terry McFadden
  Head, Fisheries Branch
  Alberta Ministry of Energy and Natural Resources
  Edmonton, Alberta

- Mr. Laurie Fowler
  Assessment Biologist
  Abernathy Salmon Cultural Development Centre
  U.S. Fish and Wildlife Service
  Longview, Washington

In order to determine the production capabilities of existing fish feed producers, we contacted the following companies that have supplied fish feed to salmonid producers in B.C.:

- M & H Feeds Inc.
  Surrey, B.C.

- Moore Clark Inc.
  La Conner, Washington

- Bioproducts Inc.
  Warrenton, Oregon

- Murray Elevators Division
  Sterling H. Nelson & Sons Inc.
  Murray, Utah

- Ritchie-Smith Feeds Inc.
  Abbotsford, B.C.

In order to determine the likely capital and operating costs of a fish feed mill, we contacted representatives of feed mills in other parts of Canada and the U.S. as well as a number of feed mill equipment suppliers. A list of the organizations contacted is provided below:

- Mr. Lee Corey
  Eastern Fish Farm Supply
  Fredericton, New Brunswick

- Mr. Jim Langtree
  Victor Fox Foods
  Winnipeg, Manitoba

- Mr. Chuck Martin
  Martin Feeds
  Elmira, Ontario

- Mr. Michael Bejerson
  Lafondree St. Anselme
  St. Anselme, Quebec

- Mr. Dan Taylor
  Sprout Waldron Inc.
  Portland, Oregon

- Mr. Chuck Kunde
  California Pellet Mill Co.
  Portland, Oregon

We also contacted the following fish meal producers, fish processors and brokers to determine the availability and price of the raw materials needed for the manufacture of fish feed:

- Mr. John Kilpatrick
  Director
  Corporate Research and Development
  B.C. Packers Ltd.
  Richmond, B.C.

- Mr. Don Sinclair
  Aquaculture Manager
  J.S. MacMillan & Co.
  Vancouver, B.C.

- Mr. Dan Byle
  President
  Langwood Farms Ltd.
  Fort Langley, B.C.

- Mr. Blair Andrews
  Broker
  Shafer-Hagart Ltd.
  Vancouver, B.C.

- Mr. Alan Doohaniuk
  Marketing Manager
  West Coast Reduction Ltd.
  Vancouver, B.C.

In order to assess the viability of fish silage as an alternative fish feed, we contacted the following university and government researchers in Canada, U.S. and Norway:

- Mr. Ronald Hardy, Ph.D.
  Supervisory Research Chemist
  Northwest and Alaska Fisheries Center
  Seattle, Washington

- Mr. David Higgs, Ph.D.
  Chief Nutritionist
  Smolt Culture
  Department of Fisheries and Oceans
  West Vancouver, B.C.

- Mr. Michael Gordon
  Program Manager
  Aquaculture and Fish Biology
  Fisheries Technology Division
  B.C. Research
  Vancouver, B.C.

- Mr. Torbjorn Asgard
  Research Station for Salmonids
  Sunndalsora, Norway

- Mr. Dag Moller
  Director of Research
  Directorate of Fisheries
  Bergen, Norway

- Mr. Trygve Tjedren
  Institute of Aquaculture Research
  Aas, Norway

We also contacted the following representatives of fish silage plants and equipment suppliers in Norway to determine the likely capital and operating costs of a fish silage plant:

- Mr. Ben Heide
  President
  Christiansen
  Aas, Norway

- Mr. Dag Baekkedal
  Sales Representative
  Senta A/S
  Hamar, Norway

- Mr. Sven Arnth Helland
  President
  Helland Mek Verksted
  Algard, Norway

The following chapter of the report contains our findings regarding the market for fish feed in Western Canada and the United States. Chapter 3 contains our analysis of the viability of establishing a feed mill in B.C. Chapter 4 provides our findings regarding the likely viability of establishing fish silage systems that could be operated by fish processors or fish farmers. The last chapter of the report contains our conclusions and recommendations regarding the conditions required for a feed mill or a fish silage system to be viable in B.C.

TABLE I

MARKET FOR FISH FEED IN B.C. IN 1984
(TONNES)

Market Segment	Dry Feeds	Moist Feeds	Semi-Moist Feeds	Total
Commercial Salmon Farms	400	5	5	410
Commercial Trout Farms	200	-	-	200
Federal Government Salmon Hatcheries	15	650	40	705
Provincial Government Trout Hatcheries	80	10	5	95
Total	695	665	50	1,410

Source: Don Ference & Associates Ltd.

II. MARKET FOR FISH FEED

This chapter contains our findings and conclusions regarding the market for fish feed in B.C., Canada and the United States. For each market investigated, we have undertaken research to determine the current size of the market and the marketing opportunities for B.C. fish feed producers.

A. CURRENT SIZE OF THE B.C. MARKET

In order to determine the current size of the B.C. fish feed market, we contacted both the major users of fish feed and the fish feed producers that currently supply the B.C. market. Based on this information, the volume of fish feed consumed in B.C. in 1984 is estimated to be a total of 1,410 tonnes as shown in Table I on the opposite page. A description of the individual market segments comprising the B.C. fish feed market is provided below:

1. Commercial Salmon Farms

As shown in Table I, commercial salmon farms consumed approximately 410 tonnes or 29% of the total fish feed used in B.C. in 1984. According to statistics maintained by the B.C. Ministry of Environment, a total of 42 permits were issued to individual commercial salmon farms in 1984.

The major type of fish feed consumed by commercial salmon farms in B.C. is a dry pellet. Dry fish feed pellets have a moisture content of 10% and are used to feed fish during their grow-out phase. Dry pellets are also used to feed brood stock maintained for egg production.

As shown in Table I, commercial salmon farmers also use a small proportion of moist and semi-moist feeds. These feeds are for the fingerlings raised in private hatcheries operated by the commercial salmon farmers. The production process for moist and semi-moist feeds is different and more complicated than for dry pelleted fish feeds. Instead of using conventional pelleting equipment, the moist and semi-moist feeds are produced using specialized extrusion equipment.

Moist fish feed pellets have a moisture content of about 30%. Due to their high moisture content, these moist pellets must be kept frozen to prevent spoilage. The semi-moist pellets are a recent alternative to moist fish feed and have a moisture content of 22%. These pellets are packaged in a nitrogen filled container in order to prevent spoilage. Because these semi-moist pellets do not have to be kept frozen, they are more attractive to commercial salmon farmers that do not have cold storage facilities.

2. Commercial Trout Farms

The total volume of fish feed consumed by commercial trout farms in 1984 is estimated to be approximately 200 tonnes or 14% of the total B.C. market. The majority of the trout farmers in B.C. are located in the Fraser Valley.

As shown in Table 1, the commercial trout farms used only dry pelleted feeds which are fed to both fingerlings and fish in the grow-out phase. The dry fish feed pellets used by the commercial trout farmers, however, are lower in fish meal content than the dry pellets purchased by commercial salmon farms. In addition, the pellets used by the trout farmers are smaller in size.

3. Federal Government Salmon Hatcheries

As shown in Table 1, the salmon hatcheries funded by the Salmonid Enhancement Program (SEP) administered by the Department of Fisheries and Oceans (DFO) accounted for approximately 705 tonnes or one-half of the total fish feed market in B.C. At the present time, there are a total of 21 individual salmon hatcheries throughout B.C. that are funded by the Salmonid Enhancement Program. These salmon hatcheries produce fingerlings which are subsequently released into the Pacific Ocean to replenish the wild stocks of salmon.

Moist pellets accounted for about 92% of the total fish feed purchased through the Salmonid Enhancement Program. As shown in Table 1, SEP hatcheries also consumed a small volume of semi-moist and dry fish feed pellets. The semi-moist pellets are used by those hatcheries lacking freezing facilities, while the dry fish feed pellets are fed primarily to brood stock or other adult fish maintained for experimental purposes.

4. Provincial Government Trout Hatcheries

The trout hatcheries operated by the B.C. Ministry of Environment purchased a total of 95 tonnes in 1984. The major feed purchased by these hatcheries consisted of small dry pellets which are used for the production of rainbow and brook trout fingerlings. A small volume of semi-moist pellets were also used by the hatcheries that produce steelhead and cutthroat trout fingerlings. In addition, the Ministry operates a salmon hatchery on contract with DFO which uses moist feed.

5. Summary

There exist two distinct market segments for fish feed. As shown in Table I, one major market segment is dry fish feeds which accounted for about 695 tonnes or slightly less than one-half of the total volume of fish feed consumed in B.C. in 1984. As mentioned previously, this dry feed is consumed primarily by commercial salmon and trout farmers.

The other major market segment consists of moist and semi-moist feeds. These feeds require a different production process and are consumed primarily by federal and provincial government fish hatcheries.

B. SUPPLIERS

A list of the major suppliers of fish feed to the B.C. market in 1984 is as follows:

British Columbia

- M & H Feeds Inc., Surrey
- Nanaimo Farmers' Co-operative

United States

- Moore Clark Inc., La Conner, Washington
- Murray Elevators Division, Sterling H. Nelson & Sons Inc., Murray, Utah
- Bioproducts Inc., Warrenton, Oregon

TABLE 2

SOURCE OF SUPPLY OF FISH FEED
TO B.C. IN 1984
(TONNES)

Source of Supply	Dry	Moist	Semi-Moist	Total
B.C.	410	-	-	410
U.S.	285	665	50	1,000
Total	695	665	50	1,410

Source: Don Ference & Associates Ltd.

A breakdown of the volume of fish feed supplied to the B.C. market by B.C. and U.S. suppliers in 1984 is provided in Table 2 on the opposite page. As indicated, B.C. feed mills supplied only about 410 tonnes or 29% of the total B.C. fish feed market in 1984. The balance of the local market requirements was supplied by fish feed producers in the United States.

1. Moist and Semi-Moist Feeds

As shown in Table 2, the moist and semi-moist fish feed consumed in B.C. was supplied entirely by U.S. fish feed producers. The moist fish feed consumed in B.C. was supplied by Moore Clark Inc. located in La Conner, Washington. About 95% of the semi-moist feeds sold in B.C. was supplied by Bioproducts Inc. while the balance was supplied by Moore Clark Inc.

2. Dry Feeds

A detailed breakdown of the major suppliers of the dry fish feed market is provided in Table 3 on the following page. As indicated, B.C. feed mills supplied a total of 410 tonnes or 59% of the dry fish feed consumed in B.C. in 1984. Most of the fish feed produced in B.C. was supplied by M & H Feeds Inc. in Surrey. The only other producer of fish feed in B.C. in 1984 was the Nanaimo Farmers' Co-operative which produced fish feed for one salmon farm located on Vancouver Island. Nanaimo Farmers' Co-operative, however, has recently gone into receivership and has ceased production.

One other local feed mill, Ritche-Smith Feeds Inc. in Abbotsford attempted to produce fish feed about five years ago through a joint venture relationship with Ewos, a fish feed manufacturer in Finland. Due to the difficulties experienced in integrating fish feed production with the production of their livestock feeds, they ceased production in 1981.

As shown in Table 3, B.C. feed mills supplied a total of 390 tonnes or 98% of the dry fish feed requirements of commercial salmon farms in B.C. Due to their closer proximity, B.C. feed mills have a freight advantage and were able to capture almost all of this market.

TABLE 3

SOURCE OF SUPPLY OF DRY FISH FEED IN B.C. IN 1984 (TONNES)

Market Segment	B.C.	United States	Total
Commercial Salmon Farms	390	10	400
Commercial Trout Farms	20	180	200
Federal Government Salmon Hatcheries	-	15	15
Provincial Government Trout Hatcheries	-	80	80
Total	410	285	695

Source: Don Ference & Associates Ltd.

U.S. feed mills, however, supplied almost all of the dry fish feed consumed by commercial trout farms and government hatcheries. As shown in Table 3, B.C. feed mills supplied only about 10% of the dry feed required by commercial trout farmers. This low market share is due to the fact that the primary fish feed supplier in B.C., M & H Feeds Inc., has not yet developed a small size of pelleted feed to suit the requirements of trout producers.

C. MARKET RESEARCH FINDINGS

Our observations and findings regarding the degree of satisfaction with the current suppliers of fish feed are as follows:

1. All of the commercial salmon farmers contacted were satisfied with the quality of dry fish feed produced by the major local supplier, M&H Feeds Inc., in Surrey, B.C.

2. The commercial salmon fish farmers also reported that the fish feed sold by M & H Feeds Inc. was less expensive than fish feed imported from the United States.

   Some of the factors contributing to the higher cost of imported feed are additional freight costs and a duty of 5% placed on fish feed imported from the United States.

3. The commercial salmon farmers contacted reported no major delays in the deliveries of feed orders.

   The delivery service to fish farmers has also recently improved since Skantech Resources Ltd. set up a warehouse in Sechelt to distribute fish feed to local producers.

4. The trout farmers and representatives of the provincial trout hatcheries that we contacted expressed dissatisfaction with the quality of the trout feed produced in B.C.

The major problems experienced with the locally produced feed is that the pellets are too large. In addition, the pellets tend to break easily and result in an excessive amount of fines which cannot be consumed by the fish.

5. The production capabilities of the existing fish feed suppliers appear adequate to accommodate substantial growth in the fish feed market.

M & H Feeds Inc. has recently expanded their production capacity by constructing a separate production line for fish feed. As a result, they can now produce fish feed on a continuous basis. According to representatives of M&H Feeds Inc., the current production equipment has a capacity to produce up to 10,000 tonnes of dry fish feed per year. Furthermore, representatives of Moore Clark Inc. have indicated that they have sufficient capacity to supply an additional 2,000 tonnes of dry feed to the B.C. market. Since the total market for dry fish feed in B.C. is only 695 tonnes, there currently exists substantial excess production capacity to supply the B.C. fish feed market.

D. MARKETING OPPORTUNITIES

We contacted representatives of the major fish feed users to determine the likely changes in the consumption of fish feed over the next five years. Our observations and findings regarding the marketing opportunities in each segment of the B.C. fish feed market are provided below:

1. Commercial Salmon Farms

Based on the industry and government representatives contacted, the commercial salmon farming industry has the greatest potential for growth. Some of the factors which indicate the substantial growth potential of the commercial salmon farming sector in B.C. are as follows:

a. The number of permits granted by the Ministry of Environment to operate salmon farms have increased from 11 in 1983 to 42 in 1984. The future production volume, therefore, should be considerably higher than sales volume over the last five years which is shown below:

PRODUCTION OF FARM RAISED SALMON IN B.C.

Year	Amount (Tonnes)
1979	38.5
1980	146.5
1981	176.4
1982	424.1
1983	128.7

Source: B.C. Ministry of Environment

b. The changes announced in the budget recently submitted by the B.C. government allow fish farmers to qualify for financial assistance programs previously available only to farmers and provides exemptions from provincial sales tax on purchases of fish farming equipment.

In addition, the provincial government has introduced tax credits for investment in venture capital corporations engaged in qualifying activities which include aquaculture. Investors in small business venture capital corporations (SBVCC) will be permitted a venture capital tax credit equal to 30% of the equity invested in an SBVCC.

c. The major emphasis of the local salmon farming industry has switched from the production of pan-sized coho to the larger sized chinook. This switch in production should improve the viability of the industry as the market potential and price obtained for the larger sized chinook is considerably greater than pan-sized coho.

TABLE 4

ANNUAL PRODUCTION OF NORWEGIAN FARMED SALMON AND TROUT

(TONNES)

Year	Atlantic Salmon	Sea Trout	Total
1971	98	433	531
1972	146	778	924
1973	171	1,001	1,172
1974	601	1,726	2,327
1975	862	1,655	2,517
1976	1,431	2,045	3,476
1977	2,137	1,795	3,932
1978	3,540	2,105	5,645
1979	4,389	2,988	7,377
1980	4,312	3,668	7,980
1981	8,418	4,624	13,042
1982	10,695	4,627	15,322
1983	17,298	5,405	22,703
1984	22,185	3,617	25,812

Source: The Development of Salmon Farming in Norway: A Growing Export Industry Made Up Of Small Community-Based Businesses. Gordon, M.R., B.C. Research, Fisheries Technology Industry Information Reports, No. 10, February, 1984.

d. In 1985, two commercial fish farmers initiated the production of sea trout in B.C. They purchased an initial batch of 250,000 trout fingerlings and plan to increase production considerably over the next five years.

e. The proportion of eggs obtained from domestic farm fish is increasing steadily. This increasing supply of eggs from private brood stock should contribute towards greater viability in the industry as they have a lower mortality rate than eggs obtained from wild stock.

f. The market demand for farm raised salmon is very strong in both local and export markets. The strong market demand for farm raised salmon has enabled the Norwegian fish farming industry to expand very rapidly. As shown in Table 4 on the opposite page, the total production of farm raised salmon and trout in Norway has increased from 531 tonnes in 1971 to 25,812 tonnes in 1984. The major markets served by Norway are Europe and the United States. These markets could also be supplied by B.C. producers if a regular and consistent source of supply was provided.

g. On August 23, 1984, grains imported from the Prairies to B.C. for the production of fish feed became eligible for feed freight assistance from the Livestock Feed Board of Canada. By lowering the raw material costs for the domestic production of fish feed, the price paid for feed by commercial farmers should be reduced thereby improving the viability of the industry.

In summary, the local salmon farming industry is likely to exoerience subtantial expansion over the next five to ten years. This expansion will dramatically increase the consumption of dry fish feed from the current level of about 400 tonnes per year.

According to the industry representatives contacted, the use of fish feed by the commercial salmon farming sector could increase to as much as 10,000 tonnes by 1990. As a result, the production capacity of the existing fish feed producer in B.C. could possibly be reached within the next four to five years.

2. Commercial Trout Farms

The potential for growth in the trout farming industry in B.C. is considerably more limited. As shown below, the production of farm raised trout in B.C. has increased slightly from 62.9 tonnes in 1979 to 84.0 tonnes in 1983:

TROUT PRODUCTION IN B.C.

Year	Production (tonnes)
1979	62.9
1980	79.3
1981	85.1
1982	75.3
1983	84.0

Based on interviews with major trout producers in B.C., the demand for trout feed is likely to expand by about 25% during the next five years.

3. Federal Government Salmon Hatcheries

As mentioned previously, approximately 92% of the feed used by federal government salmon hatcheries consists of moist feed. Moist feed is used because previous attempts to feed dry feed to fingerlings in cold water have not been successful. As shown below, the usage of moist feed by the federal government hatcheries has increased from 275 tonnes in 1979 to 650 tonnes in 1984:

SALMONID ENHANCEMENT PROGRAM
MOIST FEED PURCHASES

Year	Volume (tonnes)
1979	275
1980	340
1981	420
1982	500
1983	590
1984	650

Source: Department of Fisheries and Oceans, Vancouver

Based on interviews with representatives of the Department of Fisheries and Oceans, the purchase of fish feed for the Salmonid Enhancement Program is not likely to increase substantially during the next five years. The SEP program is currently in a two-year transition period in which the first phase of SEP is being evaluated. As a result, significant shifts in fish production will not occur during this period.

4. Provincial Government Trout Hatcheries

Provincial trout hatcheries use primarily dry feed imported from the U.S. The volume of fish feed purchased by provincial government trout hatcheries has been stable over the last five years as shown below:

PROVINCIAL GOVERNMENT TROUT HATCHERIES
FISH FEED PURCHASES

Year	Volume (tonnes)
1979	84
1980	90
1981	100
1982	90
1983	93
1984	95

Source: B.C. Ministry of Environment

According to representatives of the B.C. Ministry of Environment, the production of trout in their hatcheries is not likely to change substantially over the next five years.

TABLE 5

MARKET FOR TROUT AND SALMON FEED IN NORTH AMERICA IN 1983 (TONNES)

	U.S.	Canada	Total
Trout			
Commercial trout farmers	27,500	2,340	29,840
Public trout hatcheries	25,000	760	25,760
	52,500	3,100	55,600
Salmon			
Commercial salmon farmers	7,000	1,860	8,860
Public salmon hatcheries	9,500	540	10,040
	16,500	2,400	18,900
Total	69,000	5,500	74,500

Source: Trout and Salmon Feed Market in North America, Alberta Agriculture, 1984.

5. Summary

In summary, the market for fish feed in B.C. is likely to increase considerably in the next five to ten years. The majority of the projected growth will likely result from an increase in the number and output of commercial salmon farms in B.C., while minimal growth is projected in the other segments of the B.C. fish feed market. Since commercial salmon farms consume primarily dry feed, additional fish feed manufacturing facilities should concentrate on dry rather than moist or semi-moist fish feed production.

E. OTHER MARKETS

As shown in Table 5 on the opposite page, the market for trout and salmon feed in North America is estimated to be a total of 74,500 tonnes in 1983. The volume of trout feed consumed was 55,600 tonnes or 75% of total market while the balance or 17,900 tonnes consisted of salmon feed.

The following paragraphs contain our findings and observations regarding the marketing opportunities for B.C. fish feed producers in immediately adjacent markets such as the Prairies and the U.S. Pacific Northwest.

TABLE 6

TROUT AND SALMON FEED MARKETS IN THE PACIFIC NORTHWEST IN 1983

Segment	Idaho	Washington	Oregon	California	Total
Commercial Salmon Farms	-	6,500	-	-	6,500
Commercial Salmon Ranches	-	-	900	-	900
Commercial Trout Farms	22,500	900	850	900	25,150
State Hatchery Programs	1,500	4,350	2,700	4,600	13,150
U.S. Fish and Wildlife Service	-	1,250	50	-	1,300
TOTAL	24,000	13,000	4,500	5,500	47,000

Source: Trout and Salmon Market in North America, Alberta Agriculture, 1984

1. Prairies

Based on a recent study commissioned by Alberta Agriculture, the market for fish feed in the Prairies is estimated to be as follows:

MARKET FOR FISH FEED
IN PRAIRIES

Segment	Volume (tonnes)
Federal Trout Hatcheries	40
Provincial Trout Hatcheries	180
Commercial Trout Farms	100
Total	320

As indicated above, the fish feed market in the Prairies is very limited. The total consumption of fish feed is estimated to be only about 320 tonnes. This feed is used primarily by government trout hatcheries and commercial trout farms.

M & H Feeds Inc. currently supplies a considerable proportion of the dry feed used by commercial trout farmers in Alberta while the government trout hatcheries obtain their feed from Murray Elevators in Murray, Utah.

According to the representatives of fish producers in Alberta, the utilization of fish feed is not likely to increase substantially over the next five years. As a result, the Prairie market provides very limited opportunities for the sale of fish feed manufactured in B.C.

2. U.S. Pacific Northwest

As shown in Table 6, fish producers in the U.S. Pacific Northwest purchased a total of 47,000 tonnes of fish feed in 1983 or 63% of the total volume of salmon and trout feed consumed in the United States. About one-half of this fish feed was consumed in Idaho which is the centre of U.S. rainbow trout production.

Since this market is adequately served by a number of local feed mills and is a considerable distance from B.C., the marketing opportunities for B.C. fish feed producers in Idaho are limited.

Another major market in the U.S. Pacific Northwest is the commercial salmon farms in Washington which consumed a total of 6,500 tonnes of fish feed in 1983. About 80% of this volume was purchased by Domsea Farms Inc. in Bremerton. Based on interviews with representatives of Domsea Farms Inc., the company is presently satisfied with its two major suppliers who are Cenex Ag Inc., and Moore Clarke Inc. As a result, it would be difficult for B.C. fish feed suppliers to capture a large part of the commercial salmon farm market in Washington.

As shown in Table 6, the third major market in the U.S. Pacific Northwest is the state hatchery programs which used a total of 13,150 tonnes of fish feed. The type of feed purchased in the past has been primarily moist feed supplied by Moore Clarke Inc. However, the Washington State Department of Fisheries has recently switched approximately one-half of their feed consumption from moist feed to a dry coho feed developed by Murray Elevators. As a result, there exists potential that this market segment could be approached with a dry rather than moist feed.

F. SUMMARY

The major marketing opportunity for B.C. fish feed producers is to supply the projected growth in the local salmon farming industry which consumes primarily dry fish feed pellets. Because dry fish feed constitute the major market opportunity, the next chapter of the report concentrates on determining the viability of establishing additional dry feed manufacturing facilities in B.C.

III. FEASIBILITY ANALYSIS OF A FISH FEED MILL

This chapter of the report provides our findings regarding the likely operating and capital costs of establishing a fish feed mill in B.C. Based on our market research findings contained in the previous chapter, we have assumed that the type of feed produced would be a dry pellet that would be sold primarily to commercial salmon farms in B.C.

A. RAW MATERIALS

Fish meal is the major ingredient in commercial salmon feed. The proportion of fish meal used in commercial salmon diets varies between 45% and 60%. Other major ingredients used in commercial fish diets are listed below:

- Dried whey
- Wheat germ meal
- Soyal meal
- Corn gluten meal
- Blood meal
- Poultry byproduct meal
- Vitamin premix
- Mineral premix
- Pellet binder
- Fish oil

In addition to the above raw materials, carotenoids are often added to the feed to provide farmed salmon with its distinctive pink colour.

The proportion of the different raw materials used in fish feed is based on well researched and carefully prepared formulations in order to ensure optimum growth rate of the fish at a mimimum cost. Within the industry, there are two kinds of different feed formulations: open and closed formula diets. Open

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TABLE 7

DRY FISH FEED MILL
ESTIMATED CAPITAL COSTS

		Cost
Land		$100,000
Buildings - Plant, warehouse and office		120,000
Equipment		
Hammermill with 20 hp motor	$ 9,000	
Pellet mill complete with dies, roll assembly and 50 hp motor	40,000	
Horizontal pellet cooler, cooler fan and cyclone	18,000	
Bucket elevator with cups and belt	7,000	
Weigh scale with 4 load cells and digital read out	7,000	
4 feeder screws and ingredient hoppers	5,000	
3-deck vibrating pellet screen including motor	8,000	
Vacuum vat oil sprayer	45,000	
Boiler - 15 hp	20,000	
Pellet crumbler	3,500	
Bagging machine	6,300	
Sewing machine	1,200	170,000
Storage Bins		
Meal bins	$85,000	
Other ingredient bins	15,000	100,000
Installation Costs and Electrical Hook Up		50,000
Sub-Total		$540,000
Contingency Allowance (20%)		110,000
TOTAL CAPITAL COSTS		$650,000

formula diets are formulations developed and requested by users. Closed formulations, on the other hand, are proprietary to the feed manufacturer and the exact combination of ingredients are not revealed to the user. Since closed formulations are more predominant than open formulations, there exists a considerable degree of secrecy and lack of information regarding the specific mix and type of ingredients used in the manufacture of fish feed.

B. PRODUCTION PROCESS

The first step required to produce dry fish feed is to individually grind the fish meal and the other meals and grains in order to reduce the size of particles and to remove any lumps or large fragments. These ingredients are then mixed together with the other materials required (such as mineral and vitamin pre-mixes and binding agents) in the proportion specified in the feed formulation.

In order to produce a pellet, the feed mixture is compressed into the conditioning chamber of the pellet mill. Steam is then added to raise the temperature of the mix and to allow it to gelatinize. This soft feed is then forced through holes in a metal circular die. The die are specifically made to produce the diameter of pellet required. The pellets extruding from the die are then cut to the desired length with a series of blades.

After leaving the pellet mill, the pellets are sprayed with fish oil. These hot pellets are then passed through a cooling chamber. The finished product is bagged in 25 kilogram polyethylene bags or stored in bins for bulk shipment.

C. CAPITAL COSTS

The capital costs to establish a feed mill to produce dry pelleted fish feed are estimated to be a total of $650,000, as indicated in Table 7 on the opposite page. The major pieces of equipment required include a hammermill, pellet mill, pellet cooler, oil sprayer, boiler, bagging machine, and storage bins for meal and other ingredients. The production rate of the feed mill shown in Table 7 is approximately 3 tonnes per hour, or an annual production, on a one-shift basis, of 6,000 tonnes per year. By operating three eight-hour shifts per day, annual capacity, therefore, could be increased to about 18,000 tonnes.

TABLE 8

DRY FISH FEED MILL
FINANCIAL PROJECTIONS

Production Volume (Tonnes)	2,000	4,000	6,000	8,000
Sales Revenue	$1,628,000	$3,256,000	$4,884,000	$6,512,000
Direct Costs				
Raw Materials	$1,365,800	$2,731,600	$4,097,300	$5,463,200
Direct Labour	60,000	120,000	180,000	240,000
Supervision	20,000	30,000	40,000	50,000
Power	16,000	32,000	48,000	64,000
Bagging	46,400	92,800	139,200	185,600
Repair and Maintenance	20,000	40,000	60,000	80,000
	$1,528,200	$3,046,400	$4,564,500	$6,082,800
Selling and Administrative Costs				
Salaries	$ 40,000	$ 50,000	$ 60,000	$ 70,000
Advertising and Promotion	2,000	3,000	4,000	5,000
Accounting and Legal	3,000	4,000	5,000	6,000
Telephone	2,000	3,000	4,000	5,000
Office Expenses	2,000	3,000	4,000	5,000
Bad Debt Allowance	16,300	32,600	48,800	65,100
Insurance	6,000	6,300	6,600	6,900
Property Taxes	15,000	15,000	15,000	15,000
Depreciation	45,600	45,600	45,600	45,600
Operating Interest	17,200	34,300	51,400	68,400
	$ 149,100	$ 196,800	$ 244,400	$ 292,000
Total Operating Costs	$1,677,300	$3,243,200	$4,808,900	$6,374,800
Net Income Before Interest on Long-term Debt and Income Taxes	$ (49,300)	$ (12,800)	$ 75,100	$ 137,200
Return on Investment	(8%)	(2%)	12%	21%

Essentially, the production process and type of equipment required to produce dry fish feed is similar to that used by the feed mills in B.C. that produce cattle, hog, poultry, horse, and other animal feeds. Due to the similarity in production processes, dry fish feed in B.C. is presently produced by a feed mill that primarily produces animal feeds.

For purposes of our analysis, we have assumed that the plant would be located on about 2 acres of industrial land in the Lower Mainland. In order to obtain shipments of raw materials such as animal and cereal meals, we have assumed that rail access is provided to the site. As shown in Table 7, we have included land costs of $100,000 and building costs of $120,000 to construct the office, plant, and warehouse space required. We have assumed the buildings constructed would require a total area of about 4,000 square feet.

D. FINANCIAL VIABILITY

In order to assess the financial viability of establishing a feed mill in B.C., we have prepared estimates of the likely revenue and operating expenses that would be incurred at a number of different production levels. As shown in Table 8 on the opposite page, we have developed financial projections for an annual production volume of 2,000, 4,000, 6,000 and 8,000 tonnes. The major assumptions that we have used in these financial projections are as follows:

1. The selling price of the dry fish feed is based on current prices paid by commercial salmon farms in B.C. The sales mix and selling price used to develop our revenue estimates are as follows:

SELLING PRICE OF DRY FISH FEED

Type of Feed	Price Per Tonne	Proportion of Total Sales	Weighted Price Per Tonne
Starter Mash	$1,030	5%	$ 51.50
Crumbles #1, 2, 3, 4	$ 950	10%	$ 95.00
Grower Diet - 3/32, 1/8, 3/16, 1/4 and 3/8 pellets	$ 750	85%	$637.50
Average Selling Price Per Tonne			$814.00

As shown above, the average selling price per tonne for dry salmon fish feed is calculated to be $814.00 per tonne.

2. In order to determine the cost of ingredients for the production of salmon fish feed, we have used the feed formulation developed for salmon by the Abernathy Salmon Cultural Development Centre in Longview, Washington. Based on this feed formulation, we have determined the cost of ingredients to produce each of the different types of feeds purchased by commercial salmon farms. A detailed analysis of the cost per tonne for each type of feed is provided in Appendix I while a summary of our calculations is provided below:

RAW MATERIAL COSTS

Type of Feed	Raw Material Cost Per Tonne	% of Total Sales	Weighted Cost Per Tonne
Starter Mash	$705	5%	$ 35.25
Crumbles	$690	10%	69.00
Grower Diet	$665	85%	565.25
Weighted Raw Material Cost		100%	$669.50

As shown above, the direct cost of raw materials to produce dry fish feed for salmon production are calculated to be $669.50. By allowing for a shrinkage rate of 2%, the raw material costs are calculated to be an average total of $682.90.

3. At a production volume of 6,000 tonnes per year, a total of five direct labour staff are required to operate the feed mill. Two employees would be required to operate the mill equipment, while two employees would operate the bagging machine to package the finished product. The other employee would be required to handle shipping and receiving duties. For purposes of our analysis, we have used an average labour cost, including fringe benefits, of $15 per hour. At a production rate of 3 tonnes per hour, therefore, the direct labour cost to produce fish feed is estimated to be $30 per tonne.

4. In addition to the direct staff, a general manager, production supervisor and a secretary/clerk would be required. As a result, the feed mill would provide employment for a total of 8 people at a production volume of 6,000 tonnes per year.

5. The cost of utilities is assumed to be $8 per tonne.

6. The cost of the bags to package the finished product is $550 per 1,000 bags. In addition, the cost of thread to sew the bags shut is estimated to be approximately $30 per 1,000 bags.

7. Repair and maintenance expenses are assumed to be approximately $10 per tonne.

8. Depreciation is calculated on a straight-line basis. The buildings are depreciated over a twenty-year period while the equipment is depreciated over ten years.

9. Interest charges for working capital are calculated to be 13.5% of the average monthly direct costs.

10. The allowance for bad debts is 1% of sales.

11. The insurance on the plant provides coverage for the buildings and equipment, raw material stock, finished goods, business interruption and product liability.

As shown in Table 8, the income before income taxes and interest charges on long-term debt, varies from a loss of $49,300 at an annual production volume of 2,000 tonnes to a net income of $137,200 at a production rate of 8,000 tonnes per year.

The return on the initial capital investment also fluctuates considerably depending on the production volume. As shown in Table 8, the return on investment increases from 12% at a production rate of 6,000 tonnes per year to 21% at an annual production volume of 8,000 tonnes.

The actual breakeven volume of the fish feed plant is calculated as follows:

$$\text{Breakeven Volume} = \frac{\text{Fixed Expenses}}{\text{Contribution Margin Per Unit}}$$

$$= \frac{\$244,400}{\$53.25}$$

$$= 4,590 \text{ tonnes}$$

As indicated above, the breakeven sales volume of the fish feed plant is estimated to be about 4,590 tonnes.

In order to determine the net income after interest charges, we have assumed that the project would be financed by an equity contribution of 25%, while the remaining financing would consist of a long-term bank loan at an interest rate of 13%. Based on this financing, the estimated net income before taxes for the fish feed mill at each production level is calculated below:

FISH FEED MILL
NET INCOME BEFORE TAXES

Sales Volume: (tonnes)	2,000	4,000	6,000	8,000
Net Income Before Interest and Income Taxes	$ (49,300)	$ (12,800)	$ 75,100	$137,200
Interest on Long-term Debt	63,400	63,400	63,400	63,400
Net Income Before Income Taxes	$(112,700)	$ (76,200)	$ 11,700	$ 73,800

As indicated above, a feed mill does not appear to be viable at a production level of 2,000 or 4,000 tonnes as the projected losses are estimated to be $112,700 and $76,200, respectively. The viability of the feed mill increases considerably above a production rate of 4,000 tonnes per year. As shown above, the net income before taxes, at an annual production rate of 6,000 and 8,000 tonnes is calculated to be $11,700 and $73,800, respectively.

In order to determine the impact of changes in selling prices, we have conducted sensitivity analyses to determine the change in the breakeven sales volume of the plant. Our calculations are provided below:

SENSITIVITY ANALYSES

Change in Selling Price	Breakeven Sale Volume
+4.0%	2,850
+2.0%	3,515
-2.0%	6,610
-4.0%	11,810

Due to the relatively low gross margin, the breakeven volume fluctuates dramatically with minor fluctuations in selling prices. As shown above, the breakeven sales volume increases from 4,590 tonnes to 11,810 tonnes with a 4% decrease in selling price. As a result, management must place considerable emphasis on ensuring that selling prices are maximized. In addition, accurate and timely cost information on raw material costs must be kept in order to ensure that adequate gross margins are maintained.

E. OTHER FACTORS AFFECTING VIABILITY

Some of the other factors affecting the long-term viability of a fish feed mill are as follows:

1. Capability for Innovation

During the last fifteen years, the quality of fish feed has improved rapidly as a result of greater knowledge regarding the nutritional requirements of fish at various stages of their lives and technological advances that allow for feed to be manufactured to meet these nutritional requirements. Several examples of the breakthroughs and improvements achieved by fish feed manufacturers are as follows:

1. The development of the Oregon Moist Pellet for salmon fry by Bioproducts Inc.

2. The development of a dry pellet for larger-sized Atlantic salmon that contains a fat content of up to 25% by Skretting in Norway. The high fat content improves the feed conversion rate of fish during their grow-out phase.

3. The development of a fish feed utilizing single cell proteins processed from petroleum by BP Nutrition Ltd. in the United Kingdom.

In order for a fish feed mill in B.C. to be viable in the long term, therefore, it must have the capability to either continuously undertake research and development to develop new products or to adapt to the innovations made by other feed mills. Some methods of providing this capability for innovation are to produce feed under license or establish joint ventures with established fish feed manufacturers in the United States or Europe that have extensive research and development facilities.

2. Availability of Herring Meal

Historically, herring meal has been the preferred meal in salmon diets because of its high protein content. Some open formula diets in the U.S. specifically state that herring meal be used, especially in the feeds for salmon fry.

Presently, the majority of the herring meal used in salmonid diets in western North America is produced in British Columbia. The three major processors of herring meal in British Columbia are as follows:

- B.C. Packers Inc.
- West Coast Reduction Ltd.
- Prince Rupert Fishermens' Co-operative Association

While some herring meal is used by M & H Feeds Inc., the majority is sold to fish feed manufacturers in the U.S. The actual volume and value of herring meal exported to the U.S. over the last five years is shown below:

EXPORTS OF HERRING MEAL
TO THE UNITED STATES

Year	Volume (tonnes)	Value
1980	3,023	$1,778,600
1981	5,175	$3,344,200
1982	2,741	$1,711,600
1983	2,797	$1,823,400
1984	3,071	$2,336,300

Source: Statistics Canada

As shown above, a total of 3,071 tonnes of herring meal were exported to the U.S. in 1984 at a value of $2.336 million.

The supply of herring meal, however, is restricted by the quotas on the herring roe fishery since existing regulations by the Department of Fisheries and Oceans prohibit the harvesting of herring for the sole purpose of reduction. In 1985, the quota for roe herring was reduced from the previous level of 35,000 tonnes to 18,000 tonnes. Based on interviews with representatives of the Department of Fisheries and Oceans, the quotas for roe herring are not likely to be increased within the next five years. Consequently, the demand for herring meal is likely to exceed the supply as fish production increases in B.C. and the U.S. Pacific Northwest. In order for a local fish feed to be viable, therefore, it is necessary that long-term supply of herring meal is secured.

3. Availability of Fish Oil

Fish oil typically constitutes about 10% of salmon diets. Fish oil is manufactured by the reduction plants in B.C. and the majority is exported to U.S. fish feed manufacturers.

Since fish oil is presently a by-product of fish meal production, the supply of a high quality fish oil suitable for fish diets is also limited. In order to be viable, a local fish feed mill would have to obtain a regular source of supply of fish oil.

4. Incremental Production by Existing Feed Mills

Due to the similar production processes, feed mills that currently produce animal feeds in B.C. can easily initiate the production of fish feed. Because the capital investment required would be not be as great, the breakeven sales volume would be considerably lower than the breakeven sales volume to establish a new fish feed mill. In addition, existing feed mills would be able to spread their existing fixed costs over a greater volume. As a result, a new fish feed would face strong cost competition from existing feed mills in B.C. should they actively pursue the fish feed market.

5. Incremental Production by Fish Processors and Fish Meal Manufacturers

The viability of establishing a fish feed mill is likely to be enhanced if it represents an incremental operation of an existing fish meal producer. The most important advantage to be obtained is a secure source of herring meal and fish oil. In addition, the initial capital costs are likely to be less as the additional land and buildings required would be less than that to construct an independent plant complete with office, plant and warehouse space. In addition, smaller storage facilities would be required for fish meal and fish oil as these would be obtained as required from the fish meal reduction plant.

The production of fish feed by fish processors, however, does not possess significant advantages as compared to establishing a completely independent fish feed mill. While fish processors would be able to provide a source of supply of fish waste, this material would have to be first processed into fish meal before it would be used to manufacture fish feed. The capital costs to establish a fish meal reduction plant, however, are very high as they exceed the capital costs of establishing a complete fish feed mill.

IV. FEASIBILITY OF A FISH SILAGE SYSTEM

This chapter contains our findings and conclusions regarding the viability of utilizing fish silage as an alternative source of fish feed.

A. INTRODUCTION

The major drawback to the production of fish meal is that it is very labour and capital intensive due to the necessity of separating the fish oil and moisture from the product. In order to produce fish feed, the fish meal must then be recombined with fish oil to produce a conventional dry fish feed pellet.

A much simpler method is to feed fish waste directly. The use of both fresh and frozen fish waste for fish feed is a common practice on marine farms in Norway. Whole fish and fish waste are also used by salmon farms in the Maritimes where the fish farms are located in close proximity to fish processing plants.

The major advantage to using fresh and frozen fish waste is that it is considerably cheaper than commercial fish feed. As an illustration, fish waste can be purchased from fish processors in B.C. for about $22 per tonne. There exists a number of drawbacks, however, to using fish waste including the following:

1. Fish waste is only available at certain times of the year when fish processors are in operation.

2. The cost of freezing and storing fish waste to provide a year round supply is very expensive.

The production of fish silage is an alternative method of using fish waste. The major advantage to this method is that fish waste can be stored for long periods of time without the need for cold storage facilities.

Fish silage production initially originated in the 1920's in Europe. Fish silage is currently produced in Denmark, Britain and Poland for use primarily in hog feeds. Fish silage has also recently been used in Norway and Scotland to produce feed for pen reared salmon and trout.

There exists a lack of conclusive research, however, regarding the feed conversion rate and the economics of silage based fish feeds as compared to conventional dry feeds. One recent study in Britain reported higher feed conversion rates with silage based feeds than a commercial dry feed fed to Atlantic salmon. Research conducted in 1981 at the Research Station for Salmonids in Sunndalsora, Norway indicated that salmon fed silage based diets showed small internal inflammations. Based on a recent conversation with representatives of this research station, no serious long-term effects, however, have been observed.

Feed trials in 1983 at the Northwest and Alaska Fisheries Centre in Seattle, Washington with co-dried fish silage (where the moisture content is reduced by heating the liquified fish silage) showed poorer weight conversions for rainbow trout than obtained with commercial dry diets. The lower feed conversion rate, however, was attributed mostly to the co-drying process. As a result, the research results regarding the feed conversion rate based on silage based feeds are not consistent.

To date, no research has been conducted in B.C. on feeding silage based feeds to Pacific salmon. However, the Department of Fisheries and Oceans have plans to commence testing of silage based feeds at its West Vancouver laboratory in the spring of 1985. For the purposes of our economic analysis, we have assumed that the feed conversion rate of silage based fish feed is equivalent to the conversion rate obtained from commercial dry diets.

B. PRODUCTION PROCESS

The production of silage based fish feed is conducted in two stages. The first stage is the production of the fish silage while the second stage involves the combining of the fish silage with a binder meal to produce a pelleted feed. The following paragraphs describe the steps required for each stage.

1. Fish Silage Production

The first step required to produce fish silage is to grind the whole fish or fish waste. Grinding is necessary to distribute the enzymes naturally present in the fish. These enzymes break down the fish tissue structures. As a result, after two or three days, the fish silage becomes liquified.

Acid is then added to the ground mix to lower the hydrogen ion concentration (pH) sufficiently to prevent spoilage. The level of acidity desired is a pH level between 4.0 and 4.5. The acids commonly used to produce fish silage include formic acid or a combination of sulphuric and formic acids. The acids can be added manually or by an automatic metering system.

Fish silage must be stored in an acid resistant container. The mixture must also be stirred occasionally. In a silo or tank, this can be accomplished using a recirculating pump.

2. Production of Silage Based Feed

Silage based feed is produced by combining fish silage with a binder meal in roughly equal quantities. The raw material for the binder meal is typically made from similar ingredients as commercial dry fish diets. As a result, the binder meal can be prepared and purchased from local feed mills that produce livestock feeds. The moisture content of the binder meal is approximately 10%.

The fish silage and binder meal are mixed in a pellet machine for normally 15 to 20 minutes. The mixture is then extruded to form a moist pellet. The moisture content of the pellet is approximately 40% to 45%. Due to the high moisture content, the fish silage becomes unstable once it is combined with the binder meal and must be fed within 20 to 30 hours.

For the purposes of our analysis, we have assumed that the production of silage based fish feed could be undertaken either by individual fish farmers who have access to a supply of fish waste or by a fish processor. The next two sections of

TABLE 9

CAPITAL COSTS FOR ON-FARM PRODUCTION OF FISH SILAGE AND SILAGE BASED FEED

Building - 250 sq. ft.	$ 3,750
Silos	18,000
Equipment:	
Recirculating Pump	4,000
Acid Metering System	150
Pellet Machine	9,000
Plastic Storage Bins	500
Installation Costs	500
Sub-Total	$ 35,900
Contingency Allowance	7,200
TOTAL CAPITAL COSTS	$ 43,100

this chapter contain our preliminary findings regarding the capital costs and viability of each of these two alternatives.

D. ON-FARM PRODUCTION OF SILAGE BASED FISH FEED

We have assumed that the volume of fish feed required by a typical fish farm would be about 100 tonnes per year. The likely capital and operating costs for a fish silage system to produce this volume are described below:

1. Capital Costs

As shown in Table 9 on the opposite page, the total capital costs for the on-farm production of silage based fish feed is estimated to be approximately $43,100. The equipment listed in Table 9 is capable of both producing the fish silage and the final pellet containing a mixture of binder meal and fish silage. The major piece of equipment required is a pellet machine which is equipped with a grinder. This machine also contains a mixer and a pellet extruder complete with die and cutter blade. The production capacity of the pellet machine is approximately 1 tonne per hour.

As shown in Table 9, the other pieces of equipment required include two pumps, an acid metering system and plastic storage bins for the binder meal. In addition, two silos each with a capacity of 25 tonnes are required to store the fish silage in order to provide a year round supply of product. The building requirements are minimal consisting primarily of a cement floor and a roof to shelter the equipment.

2. Operating Costs

The estimated operating costs for the on-farm production of silage based fish feed is shown in Table 10 on the following page. The major assumptions that we have used in these cost estimates are as follows:

1. The cost of purchasing fish waste is estimated to be approximately $22 per tonne.

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TABLE 10

ESTIMATED OPERATING COSTS
FOR ON-FARM PRODUCTION OF SILAGE BASED FISH FEED
(BASED ON A PRODUCTION VOLUME OF 100 TONNES PER YEAR)

EXPENSE ITEM		AMOUNT
Direct Costs - Production of Fish Silage:		
Raw Materials		
Fish waste	$ 1,100	
Acids	1,710	$ 2,810
Labour		900
Power		350
		$ 4,060
Direct Costs - Pellet Production:		
Binder Meal		33,000
Labour		1,200
Power		500
		$ 34,700
Repair and Maintenance Expenses		860
Depreciation		3,000
Insurance		250
Interest on Long Term Debt		4,575
TOTAL COSTS		$ 47,445
COST PER TONNE		$ 474.50

2. The cost of the acid required for fish silage is calculated as follows:

Type of Acid	Quantity (tonnes)	Cost Per Tonne	Cost Per Tonne of Silage
Sulphuric	.02	$ 580	$11.60
Formic	.01	2,260	22.60
TOTAL			$34.20

As indicated above, acid costs are calculated to be about $34.20 per tonne of fish silage produced.

3. The labour requirements are estimated to be about 1.5 man hours per tonne to produce the fish silage and 1 man hour per tonne to pellet the binder meal and fish silage. We have assumed that labour costs, including fringe benefits, would be about $12.00 per hour.

4. The fish silage and binder would be mixed together in equal proportions. The amount and cost of ingredients used in the binder meal are shown in Appendix 2. This binder meal formula is based on the formulation used in the recent feed trials with Atlantic salmon. As indicated in Appendix 2, the total cost of the binder meal is estimated to be about $660 per tonne.

5. The buildings are depreciated on a straight-line basis over 20 years while the useful life of the equipment is estimated to be ten years.

6. The financing assumed for the project consists of an equity contribution of 25% while the balance would consist of a long-term bank loan at an annual interest rate of 13%.

As indicated in Table 10, the cost of on-farm production of silage based feed is estimated to be about $474.50 per tonne. The following table provides a

comparison of the cost of on-farm production of silage based feed with the cost of commercial dry salmon feed:

COST COMPARISON OF SILAGE BASED FEED
WITH COMMERCIAL DRY DIET

Type of Feed	Cost/ Tonne	Moisture Content	Cost/tonne Dry Weight
Silage based feed	$474.50	42.5%	$825.21
Commercial feed	750.00	10.0%	833.33
Difference			$ 8.12

As demonstrated above, the cost of producing silage based feed is estimated to be $825.21 per tonne, on a dry weight basis, which is $8.12 per tonne less than the cost of an equivalent commercial feed for salmon.

One of the major drawbacks to using fish silage, however, is that it is expensive to transport fish waste since its moisture content is between 70% and 80%. In addition, the majority of existing fish farmers in B.C. are not located in close proximity to fish processing plants. Consequently, their access to adequate supplies of fish waste is limited. An analysis of the viability of transporting fish waste is provided at the end of this chapter.

E. FISH SILAGE PLANT

One other method of employing fish silage for fish feed would be to establish a fish silage plant in close proximity to major fish processing plants. A possible location for the fish silage plant would be the Lower Mainland where there exists an adequate supply of fish waste. In addition to fish meal, fish waste in the Lower Mainland is presently used for the manufacture of mink and pet feeds. Frozen roe herring carcasses are also shipped from the Lower Mainland to the United States for the production of moist salmon feeds.

Another possible location for a fish silage plant would be Vancouver Island where there currently exists a surplus of fish waste. Since existing government

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TABLE II

FISH SILAGE PLANT
ESTIMATED CAPITAL COSTS

	Amount
Land	$ 30,000
Building	$ 60,000
Equipment:	
Feeding hopper with screw	4,000
Grinder	18,500
Screw conveyor	4,000
Piping	1,500
Acid metering and Ph monitoring system	2,000
3 pumps	10,000
Other equipment	1,500
Installation costs	3,500
	$ 45,000
Storage Containers:	
1 50-tonne intermediate storage vat	9,000
3 100-tonne product storage vats	45,000
1 5,000-gallon acid storage tank	4,000
1 2,500-gallon acid storage tank	2,500
	$ 60,500
Sub-total	$ 195,500
Contingency Allowance (20%)	$ 39,100
TOTAL CAPITAL COSTS	$ 234,600

regulations do not allow for herring carcasses to be discarded, herring carcasses are currently trucked, at a loss, from fish processors on Vancouver Island to reduction plants on the Lower Mainland.

The following paragraphs contain our findings and conclusions regarding the likely capital and operating costs of establishing a central fish silage plant to serve commercial salmon farmers in B.C. This silage would be sold to individual salmon farmers who could then mix the silage with binder meal to produce their fish feed.

1. Capital Costs of a Fish Silage Plant

The capital costs required to produce fish silage on a plant scale are shown in Table 11 on the opposite page. As indicated, the total capital costs to establish a fish processing plant are estimated to be approximately $234,600. The following assumptions have been made in determining the estimated capital costs:

1. We have assumed that the fish silage plant would be located adjacent to a fish processing plant in the Lower Mainland. As a result, only an additional one-third of an acre of land would be required for the plant.

2. The building requirements are minimal and consist primarily of a cement floor and steel roof to protect the equipment.

3. The production rate of the plant is estimated to be about 4 tonnes per hour.

2. Operating Costs

The estimated costs to produce fish silage on a plant scale are provided in Table 12 on the following page for a number of different production volumes. The major assumptions that we have used to develop these cost estimates are as follows:

TABLE 12

FISH SILAGE PLANT
ESTIMATED OPERATING COSTS

Production Volume (Tonnes)	500	1,000	1,500	2,000
Direct Costs				
Fish waste	$11,000	$22,000	$ 33,000	$ 44,000
Acids	12,950	25,900	38,850	51,800
Direct Labour	1,875	3,750	5,625	7,500
Supervision	500	1,000	1,500	2,000
Power	250	500	750	1,000
Repair and Maintenance	500	1,000	1,500	2,000
	$27,075	$54,150	$ 81,225	$108,300
Selling and Administrative Costs				
Salaries	$ 1,500	$ 3,000	$ 4,500	$ 6,000
Advertising and Promotion	500	1,000	1,500	2,000
Accounting and Legal	250	500	750	1,000
Telephone	250	500	750	1,000
Office Expenses	500	1,000	1,500	2,000
Bad Debts	270	540	810	1,080
Property Taxes	3,500	3,500	3,500	3,500
Insurance	1,750	1,800	1,850	1,900
Depreciation	12,630	12,630	12,630	12,630
Operating Interest	305	610	915	1,220
Interest on Long-term Debt	13,640	13,640	13,640	13,640
	$35,095	$38,720	$ 42,345	$ 45,970
Total Expenses	$62,170	$92,870	$123,570	$154,270
Costs Per Tonne	$124.34	$ 92.87	$ 82.38	$ 77.14

1. The cost of fish waste is estimated to be $22/tonne.

2. By purchasing in large quantities, the cost per tonne for acid is likely to be less than for on-farm silage production. The cost per tonne for acid is calculated as follows:

COST OF ACID FOR FISH SILAGE

Acid	Amount (tonne)	Cost Per Tonne	Cost Per Tonne of Fish Silage
Sulphuric	.02	$ 340	$ 6.80
Formic	.01	1,910	19.10
Total			$25.90

3. Only one additional direct employee would be required to operate the fish silage plant. We have assumed that the hourly labour cost, including fringe benefits, would be $15.

4. Power costs are assumed to be $.50 per tonne.

5. Depreciation is calculated on a straight-line basis over 20 years for the buildilng and 10 years for the equipment.

6. In order to finance the project, we have assumed that an equity contribution of 25% would be made while the balance would be financed by a long-term bank loan at an interest rate of 13%.

7. Operating interest is calculated at 13.5% of the average monthly direct costs.

As shown in Table 12, total production costs for fish silage decrease from $124.34 per tonne at a production volume of 500 tonnes per year to $77.14 per tonne based on an annual production volume of 2,000 tonnes.

TABLE 13

COST COMPARISON OF SILAGE BASED FEED WITH COMMERCIAL SALMON DIET

Production Volume	Cost of Silage Based Feed Per Tonne				Cost of Commercial Salmon Diet[2]	Difference
	Silage[1]	Other Costs	Total	Cost (Dry Weight)[3]		
500	$62.17	$411.60	$473.77	$823.95	$833.33	$ 9.38
1,000	46.44	411.60	458.04	796.59	833.33	36.74
1,500	41.19	411.60	452.79	787.46	833.33	45.87
2,000	38.57	411.60	450.17	782.90	833.33	50.43

1 The costs of production of fish silage are shown as 50% of the costs calculated in Table 12 since the final feed is assumed to be made up of 50% silage.

2 The dry weight content of fish silage is 57.5%.

3 The dry weight content of the commercial salmon diet is 90%.

The fish silage produced would then be sold to individual fish farmers who would mix the silage with a binder meal and pass this mixture through a pellet machine. The equipment required by the fish farmer would be similar to that previously shown for on-farm production. The silo storage requirements, however, would probably be less as regular shipments of fish silage could be obtained from the central fish silage plant. As a result, the total capital investment required is estimated to be about $32,300. The estimated operating costs that would be incurred by an individual fish farmer to produce 100 tonnes per year of silage based feed based on this alternative, are shown below:

ON-FARM PRODUCTION OF SILAGE BASED FEED
ESTIMATED OPERATING COSTS

Expense	Amount
Binder Meal	$ 33,000
Labour	1,200
Power	500
Repair & Maintenance Expenses	645
Insurance	200
Depreciation	2,465
Interest Charges	3,150
Total Cost	$ 41,160
Cost Per Tonne	$ 411.60

In addition to purchasing the silage, the individual salmon farmer would incur a cost of about $411.60 per tonne to produce a silage based feed. A comparison of the total production costs with the current cost of commercial fish feed is provided in Table 13 on the opposite page for a number of different production volumes. In this calculation, we have assumed that the fish silage purchased would be mixed with an equal quantity of binder meal to produce the finished product.

As indicated in Table 13, the production costs of silage based feeds is less than the cost of purchasing commercial salmon feed. At a production rate of 2,000 tonnes per year, the possible savings from silage based feeds amount to

approximately $50.43 per tonne. These savings are greater than that obtained from the on-farm production of fish silage due primarily to the economies of scale offered by establishing a large plant.

The cost comparison provided in Table 13, however, does not include the additional transportation costs incurred in silage based feeds. Since both fish waste and fish silage have a moisture content of about 75%, the total weight of product transported would be considerably greater than for commercial dry diets which have a moisture content of 10%. For fish farmers that are located a considerable distance from a supply of fish waste or fish silage, the high transportation costs would make the use of silage-based feeds uneconomical.

In order to assess the impact of transportation costs on the viability of silage based feeds, we have obtained quotes to haul fish silage or fish waste from the Lower Mainland to the Sunshine Coast. A comparison of the difference in trucking costs per tonne of fish feed for silage based feeds and commercial based feeds shipped is provided below:

COMPARISON OF TRUCKING COSTS

	Trucking Cost Per Tonne	Moisture Content	Trucking Cost Per Dry Tonne	% of Total Weight	Total Cost Per Tonne
Silage Based Feed					
Fish Silage	$26.83	75%	$107.32	50%	$53.66
Binder Meal	20.00	10%	22.22	50%	11.11
Total					$64.72
Commercial Fish Feed	20.00	10%	22.22	100%	$22.22
Difference					$42.55

The incremental cost to ship silage based feed from the Lower Mainland to the Sunshine Coast is calculated to be about $42.55 per tonne. By including these additional trucking costs, therefore, the production of silage would be more economical than commercial fish feed only if total production of fish silage at a central plant is in excess of 1,500 tonnes. The transportation costs could be lower than shown above, however, if fish farmers are located closer to

their plant or transport their own fish silage when delivering fish to the Lower Mainland. As a result, it is possible that the cost savings of silage based feeds would be greater than that shown above.

V. SUMMARY

The following paragraphs contain our conclusions and recommendations regarding the viability of establishing additional fish feed manufacturing facilities in B.C.

A. CONCLUSIONS

A summary of our major conclusions is provided below:

1. The total market for fish feed in B.C. in 1984 is estimated to be about 1,410 tonnes.

   Of this total, dry fish feed accounted for 695 tonnes while the balance consisted of moist feed and semi-moist feed.

2. B.C. feed mills supplied approximately 410 tonnes of dry feed pellets or 29% of the total B.C. fish feed market in 1984.

   The remainder of the fish feed consumed in B.C. was imported from the U.S. and consisted primarily of moist and semi-moist fish feed.

3. There currently exists excess dry fish feed production capacity in B.C.

   The major fish feed producer in B.C. has recently purchased additional equipment to increase total production capacity to about 10,000 tonnes per year.

4. The market for fish feed in B.C. is likely to increase considerably within the next five years.

   The major growth is likely to result from an expansion of the commercial salmon farming sector which consumed primarily dry fish feed. While it is difficult to predict the likely rate of growth, some

of the industry representatives contacted have indicated that the projected increase in salmon production could increase total feed consumption to as much as 10,000 tonnes by 1990. As a result, the production capacity of the existing fish feed producers in B.C. could possibly be reached within the next five years.

5. The breakeven sales volume of a dry pelleted fish feed mill in B.C. is estimated to be approximately 4,590 tonnes. As a result, the fish feed market in B.C. will have to expand considerably before it would be viable to construct an independent fish feed mill in B.C.

6. There exists potential to reduce current feed costs through the use of fish silage as a substitute for fish meal in the manufacture of fish feed.

   The fish silage could either be produced on-farm or in a large scale plant and then mixed with binder meal at the fish farm. The production of silage based feeds is heavily dependent upon close proximity to an adequate supply of fish waste. In addition, due to the lack of conclusive information regarding the feed conversion rate of fish silage, it is difficult to accurately assess the viability of silage based feeds.

B. RECOMMENDATIONS

Based upon our study findings, our recommendations are as follows:

1. Additional dry fish feed manufacturing facilities should not be established in B.C. until the market demand is sufficient to achieve the breakeven volume of a fish feed mill.

2. Research should be undertaken as soon as possible to determine the feed conversion rate and suitability of using fish silage as an alternative for fish meal in commercial fish farm diets.

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APPENDIX I

RAW MATERIAL COST ESTIMATES OF DRY SALMON FEED

DON FERENCE & ASSOCIATES LTD.

RAW MATERIAL COSTS OF DRY SALMON FISH FEED

Ingredient	Cost Per Tonne	Grower Diet[1]		Crumbles[2]		Starter Mash[3]	
		% of Total	Cost/tonne of feed	% of Total	Cost/tonne of feed	% of Total	Cost/tonne of feed
Fish Meal	$ 670	50.0	$335	55.0	$368	58.0	$388
Dried Whey	770	10.0	77	10.0	77	10.0	77
Wheat Germ Meal	235	5.0	12	5.0	12	5.0	12
Wheat Mill Run	150	8.8	13	3.3	5	-	-
Blood Meal	440	10.0	44	10.0	44	10.0	44
Poultry By-Product	200	1.5	3	1.5	3	1.5	3
Vitamin Premix	4,500	1.5	67	1.5	67	1.5	67
Mineral Premix	410	1.5	6	1.5	6	1.5	6
Choline Chloride	1,750	.6	11	.6	11	.6	11
Ascorbic Acid	2,500	.1	25	.1	25	.1	25
Binder	142	2.0	3	2.0	3	2.0	3
Fish Oil	770	9.0	69	9.0	69	9.0	69
TOTAL		100.0%	$665	100.0%	$690	100.0%	$705

(1) Abernathy Production Diet A18-2(84)

(2) Abernathy Production Diet A18-2(84)

(3) Abernathy Diet S8-2(84)

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APPENDIX 2

COST OF BINDER MEAL FOR SILAGE BASED FEED

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COST OF BINDER MEAL

Ingredients	Cost Per Tonne	% of Total Weight	Cost Per Tonne of Meal
Herring Meal	$ 675	50%	$ 337
Soya Meal	273	30	82
Wheat Middling	150	14	21
Vitamins and Minerals	4,200	2.5	105
Binder	143	3.5	5
Cost of Ingredients		100%	$ 550
Manufacturing Costs (including bagging)			$ 110
TOTAL			$ 660